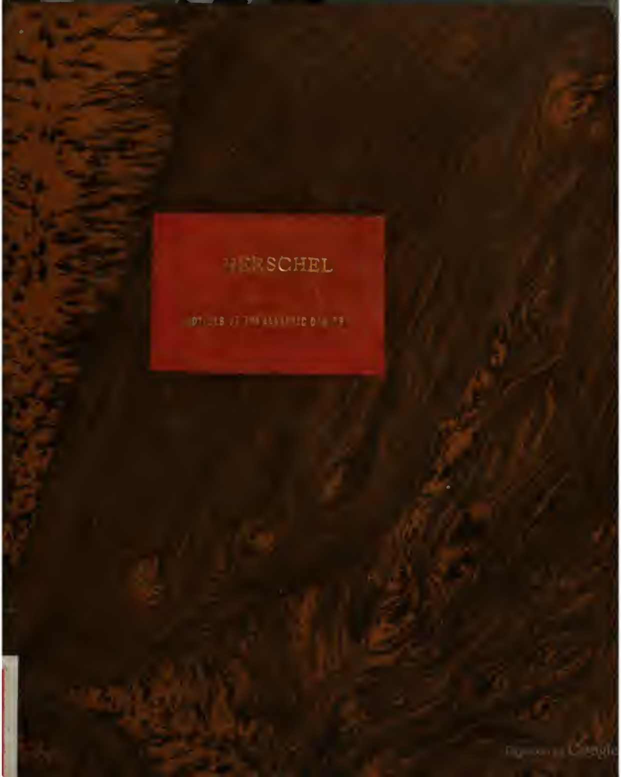

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NOTICES

OF

THE ELLIPTIC ORBITS

OF

ξ BOÖTIS AND η CORONÆ;

WITH

A SECOND APPROXIMATION TO THE ORBIT OF γ VIRGINIS.

◆

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ETC. ETC. ETC.

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BIBLIOTECA NAZIONALE VITTORIO EMANUELE III NAPOLI

Notice of the Elliptic Orbit of ξ Boötis, with a second approximation to the Orbit of γ Virginis. To which is appended, a Notice of the Elliptic Orbit of η Coronæ. By Sir J. F. W. Herschel, K.G.H., F.R.A.S., &c.

Read June 14, 1833.

The following elements and numerical formulæ, calculated by the process described in my paper "On the investigation of the Orbits of Revolving Double Stars" (*Mem. Ast. Soc.* Vol. V.), will be found to represent the existing observations of ξ *Bootis*, as well, on the whole, as they seem capable of being represented by any ellipse.

Elements.

Semiaxis major	$a = 12''{\cdot}56$	Incl. to the plane of projection, or of the sky	$\gamma = 80^\circ\ 5'$
Excentricity	$e = 0{\cdot}59374$	Position of node......	☊ $= 359^\circ\ 59'$
Position of perihelion ..	$\varpi = 138^\circ\ 24'$	Period in tropical years	$P = 117{\cdot}14$
Angle between lines of nodes and apsides..	$\lambda = 100^\circ\ 59'$	Mean motion	$n = -3^\circ{\cdot}0733$

Perihelion passage December 17, 1779.

Formulæ.

$$u - [1{\cdot}53172]\,.\,\sin u = -[0{\cdot}48760]\,.\,\{t - 1779{\cdot}96\}$$

$$\tan \tfrac{1}{2}\, v = [0{\cdot}29681]\,.\,\tan \tfrac{1}{2}\, u$$

$$\tan(\theta - 359^\circ\ 59') = [9{\cdot}23633]\,.\,\tan\{v + 100^\circ\ 59'\}$$

$$\rho = [1{\cdot}09910]\,.\,\{1 - [9{\cdot}77360]\,.\,\cos u\}\,.\,\frac{\cos(v + 100^\circ\ 59')}{\cos(\theta - 359^\circ\ 59')}$$

These elements are interesting in several respects. In the first place, the period they indicate fills up an intermediate and wanting link between the short periods of η *Coronæ*, ξ *Ursæ*, &c., and the much larger ones of *Castor*, σ *Coronæ*, 61 *Cygni*, γ *Virginis*, &c., establishing (so far as we can at present rely on such determinations) a connected scale of periods, from less than half a century to upwards of six centuries. The great amount of the excentricity of the orbit in question, strengthens the induction which already begins to assign, in no unequivocal manner, orbits rather of a cometary than a planetary character to the binary stars generally. This orbit, moreover, is the most oblique to the line of sight which has yet been calculated; and as the apparent position of the projected perihelion is not very far from making a right angle with the line of nodes, the longer axis of the real ellipse is violently foreshortened, and the whole character of the apparent ellipse completely distorted, as seen in projection from what it is in reality.

In the following comparison of the elements with observation, the distances are obtained by a mixed graphical and arithmetical process from a chart of the orbit. The positions are calculated by the formulæ.

Date of Obs.	Observer.	Observed position θ_o	Calculated position θ_c	Difference $\theta_c - \theta_o$	Observed distance ρ_o	Calculated distance ρ_c	Difference $\rho_c - \rho_o$
1782·28	Herschel	24° 7′	22° 47′	−1° 10′	< 3″,38	2″,13	″ ——
1792·30	—— (*)	355 43	358 44	+3 1	——	——	——
1795·22	——	354 56	356 59	+2 3	——	——	——
1802·25	——	352 57	353 15	+0 18	——	——	——
1804·25	——	353 54	352 17	−1 17	> 7,00	11,60	——
1819·40	Struve	345 0	343 28	−1 32	——	——	——
1821·20	South & Hers. jun.	342 32	342 27	−0 5	——	——	——
1822·63	——	340 54	341 23	+0 29	8,70	8,80	+0,10
1823·30	Amici (*)	——	——	——	6,67(*)	8,51	+1,85
1823·37	South & Hers. jun.	340 10	340 43	+0 33	——	——	——
1825·37	South	337 0	338 56	+1 56	7,78	8,12	+0,24
1828·54	Herschel, jun.	335 57	335 38	−0 19	7,18	7,35	+0,17
1830·29	——	333 27	333 40	+0 13	7,62	6,96	−0,66
1831·40	Bessel	331 15	332 0	+0 45	7,30	6,77	−0,53
1833·23	Herschel, jun.	330 43	329 15	−1 28	7,53	6,19	−1,34

The observations of 1792 and 1795, but especially the former, are obviously affected with considerable error; and either these, or those of 1802 and 1804, must be rejected, as it seems impossible to conciliate them all with any supposable orbit. Amici's measure of the distance in 1823 is evidently too small. The earlier determinations of the distance are open to too much latitude of interpretation to be of material use. The measure of 1782 includes the diameters of both stars, and when this is allowed for, the remaining central interval will be about 2½", which does not differ much from the calculated value. In 1804 the stars were declared to be too far asunder for estimation by diameters, and to be "farther apart than those of *π Boötis*." The distance of the latter star is 6",889, and since a judgment of this kind, to be decisive, supposes some considerable difference between the objects compared, it is probable that the interval between the two stars at that time must have been 9 or 10" at the least. On the whole, however, the elements represent the positions better than they do the distances; and the deviation of my last measure being considerable, it is not impossible that an ellipse somewhat less foreshortened may be nearer the truth than that above assigned; in which event, however, the amount of error in the now existing measures of position must be greater than what at present appears to belong to them.

γ Virginis.

The measures of this star, which I have procured in the current year, beginning to deviate materially from the *Ephemeris* which I published in the Supplement to the *Nautical Almanac* for 1832, I have recalculated the orbit, with the assistance of these measures, and of those which I have been able to procure from other quarters, with the exception of the measures of Professor STRUVE, which I have been unable to reconcile with the rest, and which I am compelled to believe affected by some unknown source of error. Perhaps the low situation of the star, at Dorpat, combined with the great approximation which has taken place in its component individuals, may be the cause of this; but whatever it be, I have thought it better to reject them altogether, than to vitiate the rest by any attempt to steer a middle course, without, after all, being able effectually to conciliate the measures in question with any satisfactory orbit. My recently computed elements are as follow:

Major semiaxis	$a = 12''\cdot090$
Excentricity	$e = 0\cdot8335$
Perihelion projected	$\varpi = 36^\circ\ 40'$
Perihelion from node on the orbit	$\lambda = 282\ \ 21$
Inclination to plane of the heaven	$\gamma = 67\ \ \ 2$
Node	$\Omega = 97\ \ 23$
Period in tropical years	$P = 628\cdot90$
Mean annual motion	$n = -0^\circ\cdot57242$
Perihelion passage	$\tau = 1834\cdot63$

Formulæ of Computation.

$$u - [1\cdot67901]\,.\,\sin u = + [9\cdot75772]\ \{1834\cdot63 - t\}$$

$$\tan \tfrac{1}{2}v = [0\cdot52093]\,.\,\tan \tfrac{1}{2}u$$

$$\tan (\theta - 97^\circ\ 23') = [9\cdot59142]\,.\,\tan (v - 77^\circ\ 39')$$

$$\rho = [1\cdot08228]\ \{1 - [9\cdot92089]\,.\,\cos u\} \cdot \frac{\cos (v - 77^\circ\ 39')}{\cos (\theta - 97^\circ\ 23')}$$

This premised, the comparison of the elements with the formulæ will stand as follows, the graphical process only having been employed to supersede the troublesome reduction of the last equation to numbers. And it is satisfactory to find, that while the recent observations are perfectly well represented by them, the former ones are so far from being worse expressed than by the previous elements, that they agree, on the contrary, much better; and indeed so well, throughout the whole series, as to leave nothing to desire.

Comparison of the second Orbit of γ Virginis with Observation.

Date of Obs.	Observer.	Observed position θ_o	Calculated position θ_c	Difference $\theta_c - \theta_o$	Observed distance ρ^o	Calculated distance ρ^c	Difference $\rho^c - \rho^o$
1718·20	Bradley and Pound	160° 52′	160° 57′	+0° 5′	″ —	″ —	″ —
1720·31	Cassini	—	—	—	7,49	6,74	−0,75
1756·00	Mayer	144 22	144 50	+0 28	6,50	6,29	−0,21
1780·20	Herschel	—	—	—	5,66	5,89	+0,23
1781·89	Herschel	130 44	132 6	+1 22	—	—	—
1803·20	Herschel	120 19	119 29	−0 50	—	—	—
1803·40	Herschel	—	—	—	5,90	5,12	−0,78
1819·40	Struve	—	—	—	3,56	4,00	+0,44
1820·20	Struve	105 15	104 45	−0 30	—	—	—
1822·25	Hersch. jun. & South	103 24	102 6	−1 18	3,79	3,60	−0,19
1822·50	Struve..........	102 24	101 47	−0 37	—	—	—
1823·19	Amici	—	—	—	3,30	3,44	+0,14
1825·30	Struve..........	97 58	97 13	−0 45	2,38	3,10	+0,72
1825·32	South	96 53	97 11	+0 18	3,26	3,10	−0,16
1828·35	Herschel, jun.	90 30	90 14	−0 16	—	—	—
1829·22	Herschel, jun.	87 43	87 29	−0 14	1,79	2,29	+0,50
1830·38	Herschel, jun.	82 5	82 51	+0 46	2,22	1,95	−0,27
1830·39	Dawes	81 29	82 49	+1 20	—	—	—
1830·59	Bessel	82 10	81 46	− 24	1,59	1,90	+0,31
1831·33	Dawes	78 15	77 53	−0 22	2,01	1,74	−0,27
1831·33	Herschel, jun.	77 12	77 53	+0 41	1,74	1,74	0,00
1831·36	Dawes	78 8	77 43	−0 25	1,97	1,73	−0,24
1832·25	Herschel, jun.	70 28	71 13	+0 45	—	—	—
1832·30	Dawes	69 55	70 52	+0 57	1,31	1,46	+0,15
1832·40	Captain Smyth	71 26	70 9	−1 17	1,14	1,42	+0,28
1833·10	Herschel, jun.	62 43	62 57	+0 14	1,18	1,23	+0,05
1833·23	Captain Smyth	63 38	61 35	−2 3	—	—	—
1833·24	Herschel, jun.	61 11	61 29	+0 18	1,54	1,19	−0,35

In this statement I have not included M. Struve's measures since the year 1825, as I am not sure that I should do them justice by so doing, not being in possession of his results for the current year. The angles and distances set down as the results of my own measurement, for 1833·10 and 1833·24, are concluded from an extensive series of observations, on which I am inclined to place great reliance, and the particulars of which will more properly find a place in another communication.

η Coronæ.

Having continued my observations of this interesting star whenever circumstances would permit, and having also been favoured with the communication of several valuable measures from Professor Struve and Mr. Dawes, it has at length become practicable to derive from the whole series thus amassed, by the application of the same process which has already led to so many other satisfactory results, a set of elements which represents all the observations (with a single exception) quite as well as we have any reason to expect when we consider the difficulty of the star. For convenience of present and future reference, I shall here state these measures in tabular order, taking mean results for each year, where several determinations for one and the same year by different observers occur, and denoting by capital letters the normal data with which the orbit is finally to be compared. In taking these means, the determination of each observer is considered as entitled to equal credit. A mean epoch in such cases, as well as a mean angle, is of course computed by the same rule. Where my own measures are cited, they are understood to be mean results of the observations of each year, calculated from the individual night's results according to the weights attributed to them at the time; a process troublesome in itself, but not to be dispensed with in the case of a star so difficult, where one bad set might otherwise vitiate a whole series of tolerably good observations. The individual measures will form a part of another communication which I am now preparing for the Society, and hope to complete before my departure from England.

Synopsis of observed Positions of η *Coronæ.*

A	1781·69	30° 41′	Sir William Herschel.
B	1802·69	179 40	Ditto. The original makes it 369° 40′, but this is owing to an obvious mistake of the stars one for the other.
C	1819·70	359 0	Struve, by a mean of 6 estimations of the position with the 8-feet transit. (Communicated by letter, dated March 29, 1832.)
D	1823·27	25 57	Herschel, jun. and South. Phil. Trans. 1825.
E	1826·80	35 18	Struve, by one night's measures with the great refractor. (M. Struve's letter, March 29, above cited.)
F	1829·60	43 18	Struve, by one night's obs. with the great refractor. Communicated as above.
G	1830·30	44 28	Herschel, jun. Mean of measures for 1830 in my "Measures of 364 Double Stars."
a	1831·34	50 46	Dawes. Mean of 17 measures. Communicated to me in a letter from that excellent observer.
b	1831·42	52 30	Herschel, jun. Mean of 10 nights' measures in 1831.
c	1831·60	49 48	Struve. One night's measures with the great refractor. Communicated as above.
H	1831·45	51 1	Mean of the results *a*, *b*, *c*.
d	1832·46	56 32	Herschel, jun. Mean of 4 nights' measures with the 20-feet reflector.
e	1832·50	56 48	Herschel, jun. Mean of 6 nights' measures with the 7-feet equatorial.
f	1832·77	57 1	Struve. Mean of 2 nights' observations. Communicated in a letter, dated January 4, 1833.
I	1832·58	56 47	Mean of results *d*, *e*, *f*.
K	1833·28	62 6	Herschel, jun. Mean of 8 nights' observations in 1833, the current year.

When we come to interpolate from these observations, and to compare them with the resulting ellipse, it appears that the result D cannot be employed, being affected with an amount of error such as to render all attempts to conciliate it with the rest fruitless. I have therefore excluded it from the comparison, though it has had its due weight in the determination of the elements.

Elements of the orbit of η Coronæ.

$a = 0'',8325$ $\gamma = 37° 24'$
$e = 0'',26034$ $\Omega = 220° 35'$
$\lambda = 358° 38'$ $P = 44^{y}\cdot 242$
$n = +8°\cdot 1369$

$$\tau = \text{date of perihelion passage} = \begin{cases} 1761\cdot 96 \\ 1806\cdot 20 \end{cases}$$

Formulæ for the angle of position.

$$u - [1\cdot 17366] \,.\, \sin u = [0\cdot 91046] \left\{ t - \begin{matrix} 1761\cdot 96 \\ 1806\cdot 20 \end{matrix} \right\}$$

$$\tan \tfrac{1}{2} v = [0\cdot 11572] \,.\, \tan \tfrac{1}{2} u$$

$$\tan (\theta - 220° 35') = [9\cdot 90005] \,.\, \tan (v + 358° 38')$$

Comparison of the Elements and Formulæ with Observation.

Obs.	$\theta_c - \theta_o$	Obs.	$\theta_c - \theta_o$	Obs.	$\theta_c - \theta_o$
A	−0° 42′	E	−1° 39′	H	+0° 58′
B	−1 31	F	+1 14	I	−0 3
C	+1 9	G	+2 51	K	−2 18

The orbit here assigned is remarkable, 1st, for the moderate amount of its excentricity, which hardly exceeds that of the orbits of *Mercury*, *Juno*, or *Pallas*, in our own system, and offers a nearer approach to the circular form than any orbit of a binary star which has yet been computed; 2d, on account of its situation with respect to the line of sight, the line of apsides, or axis major of the orbit, almost coinciding with the line of nodes. Owing to this we see it of its natural length, the conjugate axis only being foreshortened by the effect of perspective. The greatest distance in the apparent, or projected orbit, is 1″,049, and was attained in the year 1828. The least may be stated as 0″,5388. It was attained in the years 1800 and 1812; and will be so again in the year 1844, at which time the position indicated by these elements will be about 150°, being at present in a state of pretty rapid decrease. With this the impression on my own mind, as a matter of observation, coincides, as I cannot help fancying the stars closer at present and more difficult to separate than formerly; and Mr. Dawes assures me that he is already compelled, from this very cause, to desist from observing this star, being no longer able to separate it sufficiently to get measures he can depend upon. This is much to be regretted, since the part of its orbit at which it is now approaching, and which it will pass over within the next ten or twelve years, is the most important of any for furnishing data for improving the elements. It is to be hoped, therefore, that those who are in possession of telescopes of sufficient power, will keep a close and persevering attention on its movements, above all things *multiplying* their observations, so as to obtain, if possible, mean results depending on many hundred individual acts of measurement. It may not be uninteresting to mention, that both η and σ *Coronæ* are entitled to be regarded as triple stars; the former having a companion of the 15th magnitude, distant about 30″, in a position = 33° 59′; the latter having a much more minute one, not exceeding the 17th magnitude, situated in a position = 244° 54′, and at a distance equal to about two-thirds of that of the companion described by my Father, and measured by Sir J. SOUTH, that is to say, about 28″, but infinitely more difficult to see and measure.

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